09-29-00

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PTO/SB/05 (12/97)
Approved for use through 09/30/00. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No. 42390.P9234 Total Pages 5

First Named Inventor or Application Identifier Inching Chen

Express Mail Label No. EL627463856US

ADDRESS TO: **Assistant Commissioner for Patents**
Box Patent Application
Washington, D. C. 20231

APPLICATION ELEMENTS
See MPEP chapter 600 concerning utility patent application contents.

1. X Fee Transmittal Form
(Submit an original, and a duplicate for fee processing)

2. X Specification (Total Pages 27)
(preferred arrangement set forth below)
- Descriptive Title of the Invention
- Cross References to Related Applications
- Statement Regarding Fed sponsored R & D
- Reference to Microfiche Appendix
- Background of the Invention
- Brief Summary of the Invention
- Brief Description of the Drawings (if filed)
- Detailed Description
- Claims
- Abstract of the Disclosure

3. X Drawings(s) (35 USC 113) (Total Sheets 11)

4. X Oath or Declaration (Total Pages 5)

a. X Newly Executed (Original or Copy)

b. ___ Copy from a Prior Application (37 CFR 1.63(d))
(for Continuation/Divisional with Box 17 completed) **(Note Box 5 below)**

i. ___ DELETIONS OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).

5. ___ Incorporation By Reference (useable if Box 4b is checked)
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

6. ___ Microfiche Computer Program (Appendix)

7. __ Nucleotide and/or Amino Acid Sequence Submission
(if applicable, all necessary)
a. ____ Computer Readable Copy
b. ____ Paper Copy (identical to computer copy)
c. ____ Statement verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

8. _X_ Assignment Papers (cover sheet & documents(s))
9. __ a. 37 CFR 3.73(b) Statement (where there is an assignee)
_X_ b. Power of Attorney
10. __ English Translation Document (if applicable)
11. _X_ a. Information Disclosure Statement (IDS)/PTO-1449
_X_ b. Copies of IDS Citations
12. __ Preliminary Amendment
13. _X_ Return Receipt Postcard (MPEP 503) (Should be specifically itemized)
14. __ a. Small Entity Statement(s)
b. Statement filed in prior application, Status still proper and desired
15. __ Certified Copy of Priority Document(s) (if foreign priority is claimed)
16. _X_ Other: Express Mail Certificate and copy of postcard

17. **If a CONTINUING APPLICATION,** check appropriate box and supply the requisite information:
___ Continuation ____ Divisional ____ Continuation-in-part (CIP)
of prior application No: _

18. **Correspondence Address**
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or
_X_ Correspondence Address Below

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PTO/SB/17(6/99)
Approved for use through 09/30/2000. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

FEE TRANSMITTAL FOR FY 2000

TOTAL AMOUNT OF PAYMENT ($) $1810.00

Complete if Known:
Application No. Not yet assigned
Filing Date September 27, 2000
First Named Inventor Inching Chen
Group Art Unit Not yet assigned
Examiner Name Not yet assigned
Attorney Docket No. 42390.P9234

METHOD OF PAYMENT (check one)

1. [ ] **The Commissioner is hereby authorized to charge indicated fees and credit any over payments to:**

   Deposit Account Number 02-2666
   Deposit Account Name

   [X] **Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17**

2. X **Payment Enclosed:**
   X **Check**
   ____ **Money Order**
   ____ **Other**

FEE CALCULATION

1. **BASIC FILING FEE**

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	690	201	345	Utility application filing fee	$690.00
106	310	206	155	Design application filing fee	
107	480	207	240	Plant filing fee	
108	690	208	345	Reissue filing fee	
114	150	214	75	Provisional application filing fee	

SUBTOTAL (1) $ 690.00

2. **EXTRA CLAIM FEES**

		Extra Claims		Fee from below		Fee Paid
Total Claims	41	– 20** =	21	X 18	=	$378.00
Independent Claims	12	– 3** =	9	X 78	=	$702.00
Multiple Dependent					=	

**Or number previously paid, if greater; For Reissues, see below.

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	78	202	39	Independent claims in excess of 3
104	260	204	130	Multiple dependent claim, if not paid
109	78	209	39	**Reissue independent claims over original patent
110	18	210	9	**Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) $ 1080.00

Patent fees are subject to annual revisions. Small Entity payments must be supported by a small entity statement, otherwise large entity fees must be paid.
See Forms PTO/SB/09-12

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for response within first month	
116	380	216	190	Extension for response within second month	
117	870	217	435	Extension for response within third month	
118	1,360	218	680	Extension for response within fourth month	
128	1,850	228	925	Extension for response within fifth month	
119	300	219	150	Notice of Appeal	
120	300	220	150	Filing a brief in support of an appeal	
121	260	221	130	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive unavoidably abandoned application	
141	1,210	241	605	Petition to revive unintentionally abandoned application	
142	1,210	242	605	Utility issue fee (or reissue)	
143	430	243	215	Design issue fee	
144	580	244	290	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	40.00
146	690	246	345	For filing a submission after final rejection (see 37 CFR 1.129(a))	
149	690	249	345	For each additional invention to be examined (see 37 CFR 1.129(a))	
Other fee (specify)					
Other fee (specify)					

SUBTOTAL (3) $ 40.00

*Reduced by Basic Filing Fee Paid

SUBMITTED BY:

Typed or Printed Name: Daniel M. DeVos

Signature _____ **Date** 9/22/00

Reg. Number 37,813 **Deposit Account User ID** _____ (complete if applicable)

UNITED STATES PATENT APPLICATION

FOR

Method and Apparatus for Manipulating MPEG Video

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Attorney's Docket No. 042390.P9234

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Method and Apparatus for Manipulating MPEG Video

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

This invention relates to the field of MPEG video, more specifically to a method and apparatus for manipulating and displaying MPEG video.

BACKGROUND INFORMATION

Figure 1 (Prior Art) is a diagram of the structure an MPEG video stream. An MPEG video is an ordered stream of bits with special bit patterns marking the beginning of a section. A section corresponds to MPEG's layered structure. The layers, or levels, are sequence 101, groups of pictures (GOPs) 102, individual pictures 103, slices 105, macroblocks (MBs) 107, and blocks 109 as shown in **Figure 1** (*Overview of MPEG*, Berkley Multimedia Research). Of course, the lowest layer is the pixel layer.

In MPEG video, the layers are structured in the following manner: a sequence 101 is composed of GOPs 102; a GOP 102 is composed of pictures 103; a picture 103 is divided into slices 105; a slice 105 is composed of MBs 107; and MBs 107 are composed of blocks 109 (*Overview of MPEG*, Berkley Multimedia Research). Each picture 103 is normally encoded into one of three types of pictures, an intra coded picture (I-picture) 110, a predictive coded picture (P-picture) 112, and a bi-directionally predictive coded picture (B-picture) 114. The I-picture 110 can be decoded independently because it uses only spatial correlation within the picture. P/B-pictures 112,114 take advantage of temporal correlation to achieve a higher degree of compression by only coding the

differential data. As a result, neither P nor B pictures 112,114 can be independently decoded (*Overview of MPEG*, Berkley Multimedia Research).

Similar to pictures, there are three types of macroblocks 105: I macroblocks (I-MB), P macroblocks (P-MB), and B macroblocks (B-MB). An I-picture 110 is coded using I-MBs only. While all three types of macroblocks 105 are used to code a B-picture 114 , only I-MB and P-MB are used in coding a P-picture 112 (*Overview of MPEG*, Berkley Multimedia Research).

MPEG video has been widely used in various standards, such as DTV, DVD, and DVB. Although MPEG video decoding is currently done mostly in hardware for real-time performance, conventional hardware for MPEG video decoding is limited to the resolution of HDTV and is not capable of decoding ultra high-resolution MPEG video for a display wall.

For example, the University of Minnesota uses high-end equipment for their Power Wall. Behind the Power Wall, two SGI Power Onyx2's using multiple InfiniteReality graphics engines are controlled by a computer with a Silicon Graphics Indy control processor. The Power Wall projects a 3200X2400 resolution display 8 feet wide and 6 feet tall from 4 rear-projection monitors.

An attempt to uses software for MPEG decoding is discussed in *"Real-Time Parallel MPEG-2 Decoding in Software"*, Bilas, Fritts, and Singh, 11th Int'l Parallel Processing Symposium. Bilas et al discusses 2 software decoding approaches using a 16 processor Silicon Graphics Challenge multiprocessor (a fairly expensive multiprocessor) (*Real-Time Parallel MPEG-2 Decoding in Software*, Bilas, Fritts, and Singh, 11th Int'l Parallel Processing Symposium). First, Bilas et al uses a coarse approach by exploring

the picture level. Second, Bilas et al uses a fine-grained approach at the slice level. In the first approach, Bilas et al assigns a GOP to a processor as a task. In the second approach, Bilas et al assigns a slice to a processor as a task.

Another software approach implemented at Princeton University employs multiple interconnected personal computers (PCs) which use commodity graphics adapters for low cost. In this method, a mismatch exists between what a PC decodes and what the PC is responsible for displaying. To illustrate, PC A would decode slices representing regions to be displayed by PCs A and B. PC B must wait until node A has decoded the slices. Once PC A completes decoding, then PC A transmits the decoded data to PC B for B to display its data. The other problem is load balancing, i.e., when many slices require decoding, but only a few are to be decoded by a PC. The load imbalance occurs when the number of slices cannot be evenly distributed to all participating PCs. For example, there are 68 slices in a HDTV resolution, 1920x1088. Two of the six PCs in group A get to decode 12 slices, each, whereas the remaining four PCs in group B decode a total of only 11 slices. As a result, not all PCs in group B are busy.

Currently, very little work exists for displaying MPEG video at the high resolution of a display wall. Hardware implementations and some software implementations require costly, specialized hardware. The software implementations using conventional PCs include problems such as load balancing and communication overhead between PCs.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 (Prior Art) is a diagram of the structure an MPEG video stream.

Figure 2 is a diagram for partially decoding a picture to capture a region of interest (ROI).

Figure 3 is a conceptual diagram of the "push method" of manipulating MPEG video with Regions of Interest (ROI's), according to one embodiment of the invention.

Figure 4 is a flow chart of the client's tasks in the "push method" of manipulating MPEG video, according to one embodiment of the invention.

Figure 5 is a flow chart of the node PC thread of the "push method" at the picture level according to one embodiment of the invention.

Figure 6 is a flow chart of a node PC processing an I/P picture in the "push method" of manipulating MPEG video according to one embodiment of the invention.

Figure 7 is a flow chart of a node PC processing a B picture in the "push method" of manipulating MPEG video according to one embodiment of the invention.

Figure 8 is a conceptual diagram of the "pull method" of manipulating MPEG video, according to one embodiment of the invention.

Figure 9 is a flow chart of the client's tasks for the "pull method" of manipulating MPEG video according to one embodiment of the invention.

Figure 10 is a flow chart of the client thread for the "pull method" of manipulating MPEG video according to one embodiment of the invention.

Figure 11 is a flow chart for determining the conversion of a P/B-macroblock to an I-macroblock according to one embodiment of the invention.

DETAILED DESCRIPTION

In the following description, numerous specific details are set forth to provide a thorough understanding of the invention. However, it is understood that the invention may be practiced without these specific details. A method and apparatus for manipulating and displaying MPEG video is described.

Figure 2 is a conceptual diagram for partially decoding a picture to capture a region of interest (ROI). The ROI is an area of a picture, smaller than the entire picture, which is to be treated separately by a given device (e.g., to be displayed by the device, to be reencoded by the device, etc.). In **Figure 2A**, an ROI 201 of an MPEG encoded picture 202 is identified. In **Figure 2B**, a first slice 203 partially falling within the ROI 201 of the MPEG encoded picture 202 is decoded into multiple macroblocks 204. A set 212 of the multiple macroblocks 204 for the part of the slice falling within the ROI 201 are further decoded. In **Figure 2C**, a second slice 206 partially encompassed by the ROI is decoded into multiple macroblocks 207. In **Figure 2D**, a third slice 209 of the picture 202 is not decoded because it does not fall within the region of interest 201. In **Figure 2E**, a last slice 210 of the picture 202 also does not fall within the region of interest 201 and therefore is not further decoded. When combined, the set of macroblocks 212 and 215 in **Figure 2E** form the ROI 201. The ROI is located by partially decoding a picture without fully decoding the entire picture, thus reducing computational complexity and increasing work efficiency. In addition, a system may only extract information relevant to its ROI, and not other ROI's.

Figure 3 is a conceptual diagram of the "push method" of manipulating MPEG video with Regions of Interest (ROI's), according to one embodiment of the invention. In

the "push method", a client computer 301 broadcasts an MPEG stream 302 over a network to node computers 303-308 connected to the network. The nodes 303-308 decode their ROI's 309-314 from the MPEG stream 302. The node computers 303-308 then display their ROI's 309-314 in synchronization. Continuous synchronized display of the ROI's 309-314 collectively display the MPEG video stream 302.

Figure 4 is a flow chart of the client's tasks in the "push method" of manipulating MPEG video, according to one embodiment of the invention. At block 401, a client sends an attribute file to all nodes connected to the client over a network. After sending the attribute file, the client then begins to broadcast the MPEG stream to each of the node computers at block 402. At the same time, the client begins a synchronization task at block 403. The client's synchronization task at block 403 includes waiting for signals from the nodes on the network. A signal indicates that a node has decoded its ROI. When the client receives the signals from all desired nodes, the client sends a display command to the desired nodes. While the client broadcasts the MPEG stream over the network, it continuously performs the synchronization task. The dashed line 405 indicates the coordination between the synchronization task at block 403 and the computer sending MPEG streams at block 402. The client will not overload the node with MPEG data if the node does not have the capacity to handle any further MPEG data.

Figure 5 is a flow chart of the node PC thread of the "push method" at the picture level according to one embodiment of the invention. At block 501, a node receives an attribute file. The node then begins to receive MPEG encoded pictures at block 505 from the client. The node then determines if the picture is an I/P picture or a B-picture at block 506. At block 508, the node processes I/P-pictures. At block 507, the node processes B-

pictures. At block 520, the node determines if the buffer space is full. If the buffer space is full, then the node waits until space has been freed for the processed picture at block 525. If space is available or once space is made available, the node buffers a region of interest from the picture at block 509. At block 512, the node gets the next picture, while at the same time waiting for a display command from the client at block 515. Once the node receives the display command from the client at block 517 the node displays the ROI.

Figure 6 is a flow chart of a node PC processing an I/P picture in the "push method" of manipulating MPEG video according to one embodiment of the invention. The node gets the first slice of the picture at block 601. The server then determines if the slice is within the region of interest or a reference region in block 602. A reference region is an area surrounding an ROI. This area contains information relevant to the ROI. If at least part of the slice is not within the region of interest or its reference region, then the node discards the slice at block 603, gets the next slice of the picture at block 604, and control returns to block 602. If at least part of the slice is determined to be within the ROI or the ROI's reference region, then the node gets the first macroblock from the slice at block 605. The node then determines at block 606 whether the macroblock is within the region of interest or the reference region. If the macroblock is not within the region of interest or the reference region, then at block 608 the node determines if it has reached the end of the slice. If at block 608, it is determined that the node is not done with the slice, then at block 609 the node gets the next macroblock of the slice and control returns to 606. If at block 606 it is determined that the macroblock is within the region of interest or the reference region, then the node decodes the

macroblock at block 607 and control passes to block 608. If at block 608, it is determined that the node is done with the slice, then at block 610, the node determines if it has completed decoding its region of interest. If the node has not completed its region of interest, then it proceeds to get the next slice of the picture at block 604. If the node has completed decoding its ROI, then at block 611, it sends a "done" signal to the client.

Figure 7 is a flow chart of a node PC processing a B picture in the "push method" of manipulating MPEG video according to one embodiment of the invention. The node gets the first slice of the picture at block 701. The server then determines if the slice is within the region of interest in block 702. If at least part of the slice is not within the region of interest, then the node discards the slice at block 703, gets the next slice of the picture at block 704, and control returns to block 702. If at least part of the slice is determined to be within the ROI, then the node decodes the first macroblock from the slice at block 705. The node then determines at block 706 whether the macroblock is within the region of interest. If the macroblock is not within the region of interest, then at block 608 the node determines if it has reached the end of the slice. If at block 708, it is determined that the node is not done with the slice, then at block 709 the node gets the next macroblock of the slice and control returns to 706. If at block 706 it is determined that the macroblock is within the region of interest, then the node decodes the macroblock at block 707 and control passes to block 708. If at block 708, it is determined that the node is done with the slice, then at block 710, the node determines if it has completed decoding its region of interest. If the node has not completed its ROI, then it proceeds to get the next slice of the picture at block 704. If the node has completed decoding its ROI, then at block 711, it sends a "done" signal to the client.

The "push method" enables parallel distributed MPEG display in a multiple system environment with software decoding. Since each node PC is only responsible for a defined region of each MPEG picture of the MPEG stream, the node PCs do not need to communicate with each other. The reduction in network traffic is accompanied by an evenly distributed workload and higher utilization of the node PCs. Each node will fully decode only its ROI. Once a node PC completes decoding a ROI, the PC can begin decoding the ROI for one or more subsequent pictures, whether or not the display signal has been received (of course, based on buffer memory availability). Furthermore, the "push method" does not require high-end graphics equipment. The client and nodes can be conventional PCs.

According to another embodiment of the invention, a "pull method" of manipulating MPEG video is described. **Figure 8** is a conceptual diagram of the "pull method" of manipulating MPEG video, according to one embodiment of the invention. In the "pull method", a client computer 801 transmits multiple MPEG compliant substreams 802- 807 over a network. Each substream 802-807 corresponds to a spatial location across the sequence of pictures comprising the MPEG stream. The spatial location is less than an entire picture. Each of the MPEG compliant encoded substreams 802 through 807 are transmitted to a specific node 808-813 connected to the network. Each node 808-813 decodes its substream 802-807 and displays the decoded substream 814-819. The client computer 801 can synchronize display of the decoded substreams 814-819 to display the MPEG stream 820. The MPEG compliant substreams 802-807 are created by the client computer at 801 from the MPEG stream 820. The client 801 may only create a single substream if only one ROI is desired.

This manipulation of an MPEG video stream to create a completely independent substream eliminates the problem of communication overhead between the nodes. In addition, an MPEG compliant substream corresponding to an ROI can provide a variety of new applications for MPEG video. A user may only be interested in one region of an MPEG video. A system could create a single substream focusing on that region from the MPEG video. This single substream can be scaled or manipulated further depending on the user's requirements. Some application may require manipulation of independent substreams from different MPEG streams. If desired, a single substream could be made which tracks a roaming ROI.

Figure 9 is a flow chart of the client's tasks for the "pull method" of manipulating MPEG video according to one embodiment of the invention. At block 901, the client begins to make MPEG substreams from a main MPEG stream. While still making MPEG substreams in block 902, the client begins to send the substreams over a network at block 903. While sending the substreams and making additional substreams in with a lock-step approach, the client begins performing a synchronizing task at block 904.

Figure 10 is a flow chart of the client thread for the "pull method" of manipulating MPEG video according to one embodiment of the invention. At block 1001, the client gets an MPEG encoded picture from an MPEG stream. If at block 1002, the MPEG encoded picture is an I-picture, then the client decodes the I-picture at block 1003 to the macroblock level. At block 1004 the client separates the macroblocks into data structures according to one or more regions of interest. The client then uses the macroblocks in a data structure corresponding to one or more ROI's to construct a corresponding MPEG compliant I-picture at block 1005. According to one embodiment

of the invention, new pictures are constructed slice by slice. For I-pictures, a new slice is constructed by putting together all the I-macroblocks within the ROI. The Q-value at the slice level needs to be updated by the Q-value used to code the first macroblock. In addition, the VLC code of the DC components for Y, Cr, and Cb of the first macroblock, require updates because they are coded losslessly by a DPCM technique. At each start of a slice, DC_DCT_PRED is reset and a new DC_DIFF value is calculated.

It is determined at block 1006 if the MPEG encoded picture is a P/B-picture. If the picture is a P/B-picture, then the client decodes the picture to the macroblock level at block 1007. It is determined at block 1009 if the MB is a P/B-MB. For those MBs that are P/B-MB, the client at block 1010 determines if each of the P/B-macroblocks require conversion to an I-macroblock. One exemplary embodiment of block 1010 is later described in more detail with reference to **Figure 11**. At block 1012, the client separates macroblocks into data structures according to one or more ROI's. At block 1015, the client then uses the MBs of each of the region(s) to construct an MPEG compliant P/B-picture. According to one embodiment of the invention, new pictures are constructed slice by slice. Like an I-picture, the Q-value of the first macroblock needs to be updated at a slice or macroblock level. If the first macroblock of the slice is an old I-macroblock, then the DC_DIFF values need an update just like an I-picture. However, if the first macroblock is a new I-macroblock and is followed by an I-macroblock, the DC_DIFF values of the following I-macroblock need to be updated. Similar to the DC_DCT_PRED, the MV is coded differentially with respect to previous decoded MV, and uses VLC. However, there are some differences. Forward MV and backward MV should be treated independently, because a B-MB can be decoded with forward MV

and/or backward MV. A skipped MB has different effects on P- and B-pictures. In a P-picture, the PRED_MV is reset to zero when a MB is skipped. However, the PRED_MV are not affected in a B-picture.

Figure 11 is a flow chart for determining whether the conversion of a P/B-macroblock to an I-macroblock is required (block 1012), according to one embodiment of the invention. At block 1101 the client determines if a P/B-macroblock's reference macroblock is out of the region of interest. A reference MB contains information needed by a MB, such as motion compensation information. If the reference macroblock is out of the region of interest, then the client converts the P/B-MB to an I-MB at block 1105. In one embodiment of the invention, a MB is converted to an I-MB by decoding the P/B-MB to the pixel level and then encoding the pixels as MPEG compliant I-MBs. All MBs converted to I-MBs are encoded as if the first MB of a slice. If the P/B-MBs reference MB is not beyond the ROI, then the client determines if the P/B-macroblock is a skipped macroblock at block 1102. If the P/B-MB is not a skipped MB, then at block 1106 the client stores the P/B-MB into a data structure according to region of interest. If the P/B-MB is a skipped MB, then it is determined if the P/B-MB will be at the beginning or end of a new slice at block 1103. If the P/B-macroblock will be at the beginning or the end of a new slice, then the P/B-macroblock is converted to an I-MB at block 1105. If the P/B-macroblock will not occur at the beginning or end of a new slice, then it is determined if the skipped P/B-macroblock will follow a new I-macroblock in a B-picture in block 1104. If the skipped macroblock does not follow a new I-macroblock in a B-picture, then the client stores the P/B-macroblock in a data structure according to region of interest at block 1106. If the skipped P/B-macroblock does follow a new I- macroblock in a B-

picture, then the client converts the skipped P/B-macroblock to an I-macroblock at block 1105. Converted I-macroblocks are stored after conversion into one or more data structures according to region of interest at block 1106.

Like the "push method", the "pull method" also manipulates MPEG video enabling parallel distributed MPEG video display in a multiple system environment with software decoding. As in the "push method", the "pull method" doesn't require communication between the nodes. In addition, network traffic is further reduced because the client transmits substreams for one or more ROI's instead of the entire MPEG stream to each node. The nodes can use a conventional MPEG decoder since the substreams are MPEG complaint. Moreover, the workload can be evenly balanced across the nodes because the nodes are only responsible for a substream representing their ROI.

The techniques shown in the figures can be implemented using code and data stored and executed on computers. Such computers store and communicate (internally and with other computers over a network) code and data using machine-readable media, such as magnetic disks; optical disks; random access memory; read only memory; flash memory devices; electrical, optical, acoustical or other form of propagated signals (e.g., carrier waves, infrared signals, digital signals, etc.); etc. Of course, one or more parts of the invention may be implemented using any combination of software, firmware, and/or hardware.

While the invention has been described in terms of several embodiments, those skilled in the art will recognize that the invention is not limited to the embodiments described. The MBs in the "pull method" can be stored in a variety of data structures, e.g., trees, tables, lists, hybrid trees, etc. The system may be set up to store MBs for

newly constructed slices and immediately sending the slices. Another embodiment of the invention would utilize a data structure corresponding to ROI's and a buffer to store more than one constructed picture corresponding to an ROI before transmission. The method and apparatus of the invention can be practiced with modification and alteration within the spirit and scope of the appended claims. The description is thus to be regarded as illustrative instead of limiting on the invention.

CLAIMS

What is claimed is:

1. A computer implemented method comprising:

defining a spatial location across a series of pictures of an MPEG stream; and

for each picture of the series of pictures in the MPEG stream, partially decoding the picture to determine an area of the picture falling within the spatial location.

2. The method of claim 1 further comprising fully decoding at least the spatial location in the picture, but not all of the picture.

3. The method of claim 1 further comprising forming a plurality of substreams from the partially decoded MPEG stream.

4. A computer implemented method comprising:

decoding a picture of an MPEG stream into a plurality of slices having a set of slices at least partially within an area of the picture, the area being less than all of the picture;

decoding at least the set of slices but not the plurality of slices into a plurality of macroblocks having a set of macroblocks within the area; and

decoding at least the set of macroblocks but not the plurality of macroblocks into pixels.

5. The method of claim 4 wherein the area is a region of interest.

6. The method of claim 4 further comprising displaying the decoded set of macroblocks.

7. A computer implemented method comprising:

creating an MPEG compliant substream from an MPEG stream including a plurality of pictures, the substream corresponding to a region of interest (ROI), said ROI being an area of each picture of the plurality of pictures smaller than the total area of each picture; and

transmitting the substream.

8. The method of claim 7 further comprising synchronizing display of the substream with a second MPEG compliant substream from the MPEG stream.

9. The method of claim 7 wherein the creation and transmission of the substream are performed in a lock-step manner.

10. A computer implemented method comprising:

a client defining a region of interest (ROI) for each of a plurality of nodes;

the client transmitting an attribute file to the plurality of nodes, said attribute file including the defined regions of interest;

the client broadcasting an MPEG stream to the plurality of nodes, the MPEG stream having a series of pictures;

for each picture in the series of pictures of the MPEG stream, each of the plurality of nodes,

partially decoding an area of the picture including at least the defined ROI,

fully decoding the defined ROI,

buffering the ROI; and

the client directing display of each picture in the series of pictures.

11. The method of claim 10, wherein the client commanding display of the picture comprises:

waiting for a signal from each of the plurality of nodes that the ROI has been decoded; and

transmitting a command to the plurality of nodes to display their ROI.

12. The method of claim 10 further comprising a lock-step mechanism for buffering a fully decoded picture.

13. A computer implemented method comprising:

a client decoding a picture from an MPEG stream;

the client selecting a Region of Interest in the picture;

the client constructing a new MPEG picture corresponding to the region of interest;

the client transmitting the new MPEG picture to a node; and

the client commanding the node to display the new MPEG picture.

14. The computer implemented method of 13 wherein the picture is an I-picture and the client constructing the new MPEG picture comprises:

decoding the I-picture into a plurality of macroblocks;

storing the plurality of macroblocks into a plurality of data structures, each of the plurality of data structures corresponding to a different one of the plurality of regions of interest; and

forming a new MPEG compliant I-picture from the macroblocks stored in one of the plurality of data structures.

15. The computer implemented method of 13 wherein the picture is a P/B-picture and the client constructing the new MPEG picture comprises:

decoding the P/B-picture into a plurality of slices;

decoding each slice of the plurality of slices into a plurality of macroblocks;

if a macroblock of the plurality of macroblocks is an I-macroblock, storing the I-macroblock into one of a plurality of data structures, each of the plurality of data structures representing a different one of the plurality of regions of interest;

if the macroblock of the plurality of macroblocks is a P/B-macroblock having at least one reference macroblock and if the reference macroblock is out of the represented region of interest, converting the P/B-macroblock into a new I-macroblock;

if the macroblock of the plurality of macroblocks is a P/B-macroblock and the P/B-macroblock is a skipped macroblock and follows a new I-macroblock

and the picture is a B-picture, converting the P/B-macroblock into a new I-macroblock;

if the macroblock of the plurality of macroblocks is a P/B-macroblock and the P/B-macroblock is a skipped macroblock and will occur at the beginning or end of a new slice, converting the P/B-macroblock into a new I-macroblock;

storing the new I-macroblocks and remaining P/B-macroblocks of the plurality of macroblocks into the plurality of data structures;

forming a new slice with the macroblocks stored in one of the plurality of data structures;

accumulating a plurality of the new slices; and

forming an MPEG compliant P/B-picture by encoding the plurality of the new slices.

16. The method of claim 13, wherein the regions of interest are different spatial locations of the picture which form the picture when combined.

17. The method of claim 13 wherein the regions of interest are overlapping areas of the picture which form the picture when combined.

18. The method of claim 13 further comprising commanding a second node to display a second new picture from the picture in synchronization with display of the new picture.

19. An apparatus comprising:

a network;

a first computer on the network,

to divide a picture of an MPEG stream into a plurality of regions,

to broadcast the picture over the network, and

a plurality of computers on the network, each of the plurality of computers,

to partially decode an area of the picture, said area of the picture corresponding to one of the plurality of regions,

to fully decode the corresponding one of the plurality of regions; and

to display the fully decoded one.

20. The apparatus of claim 19 further comprising:

the first computer to transmit an attribute file over the network, said attribute file having a definition of the plurality of regions.

21. The apparatus of claim 19 further comprising:

the first computer to synchronize display of the plurality of regions to form the picture.

22. An apparatus comprising:

a network to connect a first computer to a plurality of computers;

the first computer

to construct a plurality of MPEG substreams from a source MPEG stream,

to transmit each of the plurality of MPEG substreams to a corresponding computer of the plurality of computers, and

each of the plurality of computers to display one of the plurality of MPEG substreams.

23. The apparatus of claim 22 further comprising:
the first computer to synchronize display of the plurality of MPEG substreams.

24. The apparatus of claim 22 further comprising:
each of the plurality of nodes to decode one of the plurality of MPEG substreams with a conventional MPEG decoder.

25. An apparatus comprising:
a network to connect a client to a plurality of nodes;
the client to assign a region of an MPEG encoded picture to at least one of said plurality of nodes, the region being smaller than the picture; and
each of the plurality of nodes to display its assigned region of the picture.

26. The apparatus of claim 25 wherein the client to assign each of the plurality of regions comprises:
the client transmitting one of the plurality of regions to at least one of the plurality of nodes.

27. The apparatus of claim 25 wherein each of the plurality of nodes display its region of the picture in synchronization.

28. The apparatus of claim 25 wherein the client to assign each of the plurality of regions comprises:

dividing the MPEG encoded picture into a plurality of new MPEG compliant pictures, each of the plurality of new MPEG compliant pictures forming the MPEG encoded picture when combined.

29. The apparatus of claim 25 wherein each of the plurality of nodes to display its region of the picture comprises:

each of the plurality of nodes partially decoding the MPEG encoded picture; and

each of the plurality of nodes further decoding its region of the MPEG encoded picture.

30. A machine-readable medium that provides instructions, which when executed by a set of processors, cause said set of processors to perform operations comprising:

defining a spatial location across a series of pictures of an MPEG stream; and

for each picture of the series of pictures in the MPEG stream, partially decoding the picture to determine an area of the picture falling within the spatial location.

31. The machine readable medium of claim 30 that provides instructions, which when executed by a set of processors, cause said set of processors to perform operations further comprising fully decoding at least the spatial location in the picture, but not all of the picture.

32. The machine readable medium of claim 30 that provides instructions, which when executed by a set of processors, cause said set of processors to perform operations further comprising forming a plurality of substreams from the partially decoded MPEG stream.

33. A machine-readable medium that provides instructions, which when executed by a set of processors, cause said set of processors to perform operations comprising:

decoding a picture of an MPEG stream into a plurality of slices having a set of slices at least partially within an area of the picture, the area being less than all of the picture;

decoding at least the set of slices but not the plurality of slices into a plurality of macroblocks having a set of macroblocks within the area; and

decoding at least the set of macroblocks but not the plurality of macroblocks into pixels.

34. The machine readable medium of claim 33 wherein the area is a region of interest.

35. The machine readable medium of claim 33 further comprising displaying the set of decoded macroblocks.

36. A machine-readable medium that provides instructions, which when executed by a set of processors, cause said set of processors to perform operations comprising:

creating an MPEG compliant substream from an MPEG stream including a plurality of pictures, the substream corresponding to a region of interest

(ROI), said ROI being an area of each picture of the plurality of pictures smaller than the total area of each picture; and

transmitting the substream.

37. The machine readable medium of claim 36 that provides instructions, which when executed by a set of processors, cause said set of processors to perform operations further comprising synchronizing display of the substream with a second MPEG compliant substream from the MPEG stream.

38. The machine readable medium of claim 36 further comprising a lock-step mechanism governing the creation and transmission of the substream.

39. A machine-readable medium that provides instructions, which when executed by a set of processors, cause said set of processors to perform operations comprising:

a client defining a region of interest (ROI) for each of a plurality of nodes;

the client transmitting an attribute file to the plurality of nodes, said attribute file including the defined regions of interest;

the client broadcasting an MPEG stream to the plurality of nodes, the MPEG stream having a series of pictures;

for each picture in the series of pictures of the MPEG stream, each of the plurality of nodes,

partially decoding an area of the picture including at least the defined ROI,

fully decoding the defined ROI,

buffering the ROI; and

the client directing display of each picture in the series of pictures.

40. The machine readable medium of claim 39, wherein the client commanding display of the picture comprises:

waiting for a signal from each of the plurality of nodes that the ROI has been decoded; and

transmitting a command to the plurality of nodes to display their ROI.

41. The machine readable medium of claim 39 further comprising a lock-step mechanism for buffering the fully decoded ROI.

ABSTRACT OF THE DISCLOSURE

A computer implemented method of manipulating and displaying an MPEG stream is described. In one embodiment of the invention, a computer implemented method comprises defining a spatial location across a series of pictures of an MPEG stream; and for each picture of the series of pictures in the MPEG stream, partially decoding the picture to determine an area of the picture falling within the spatial location.

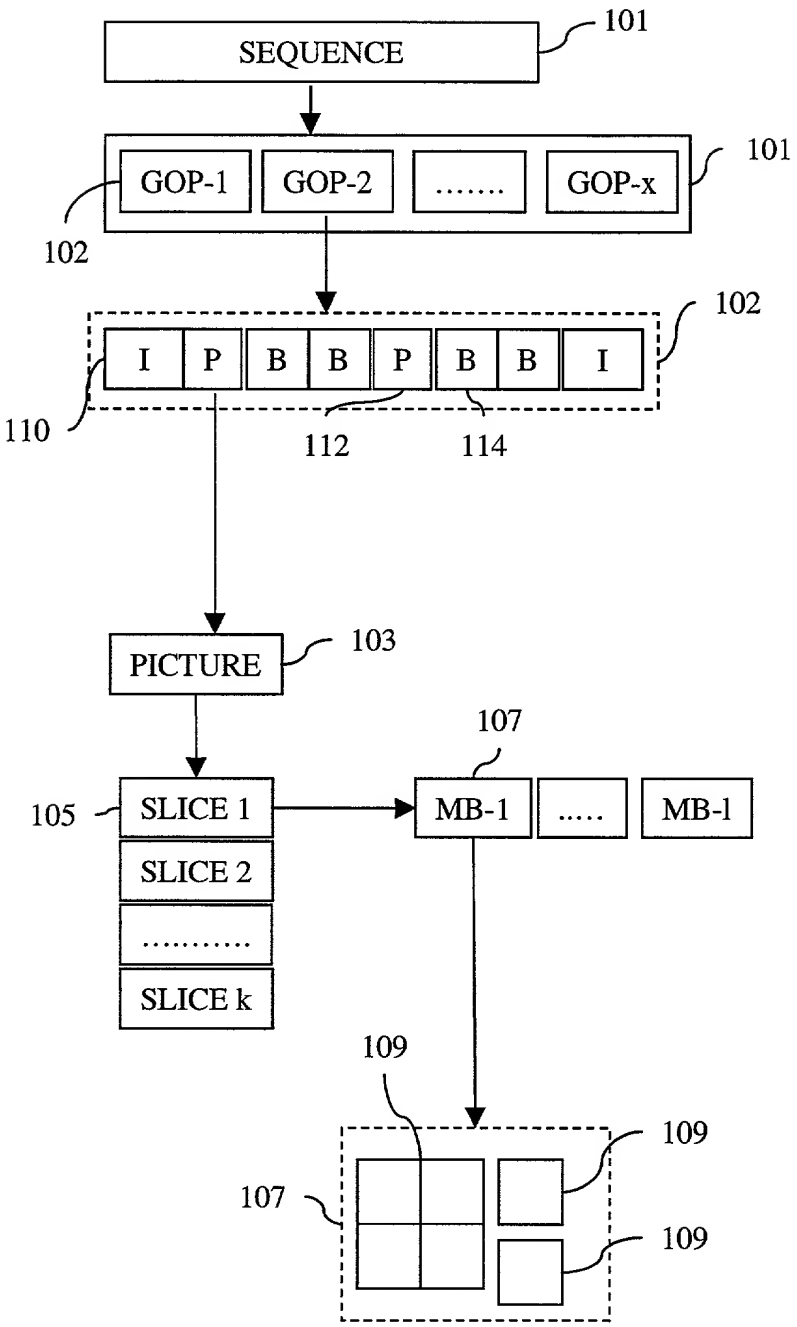


Fig. 1 (PRIOR ART)

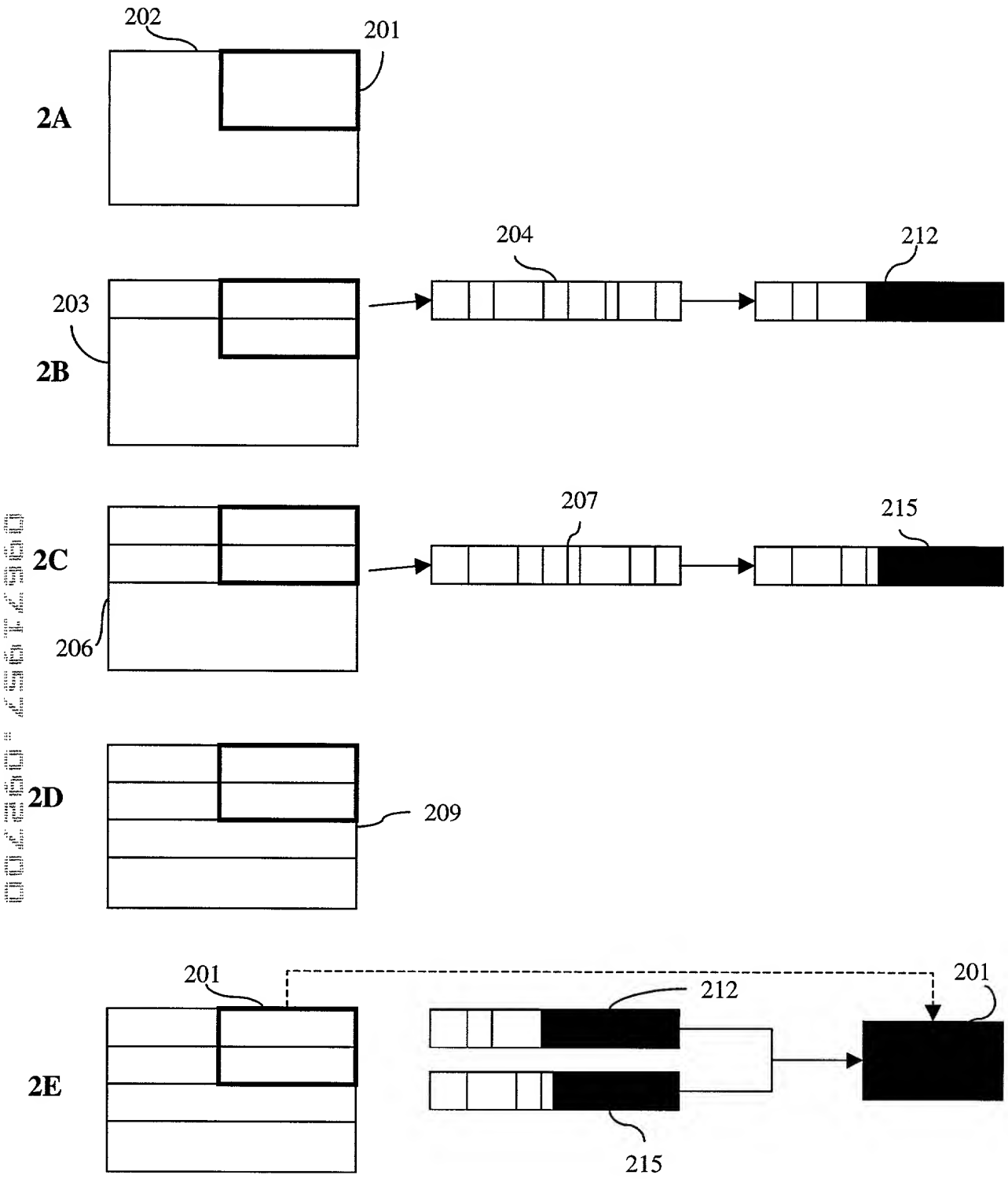


Fig. 2

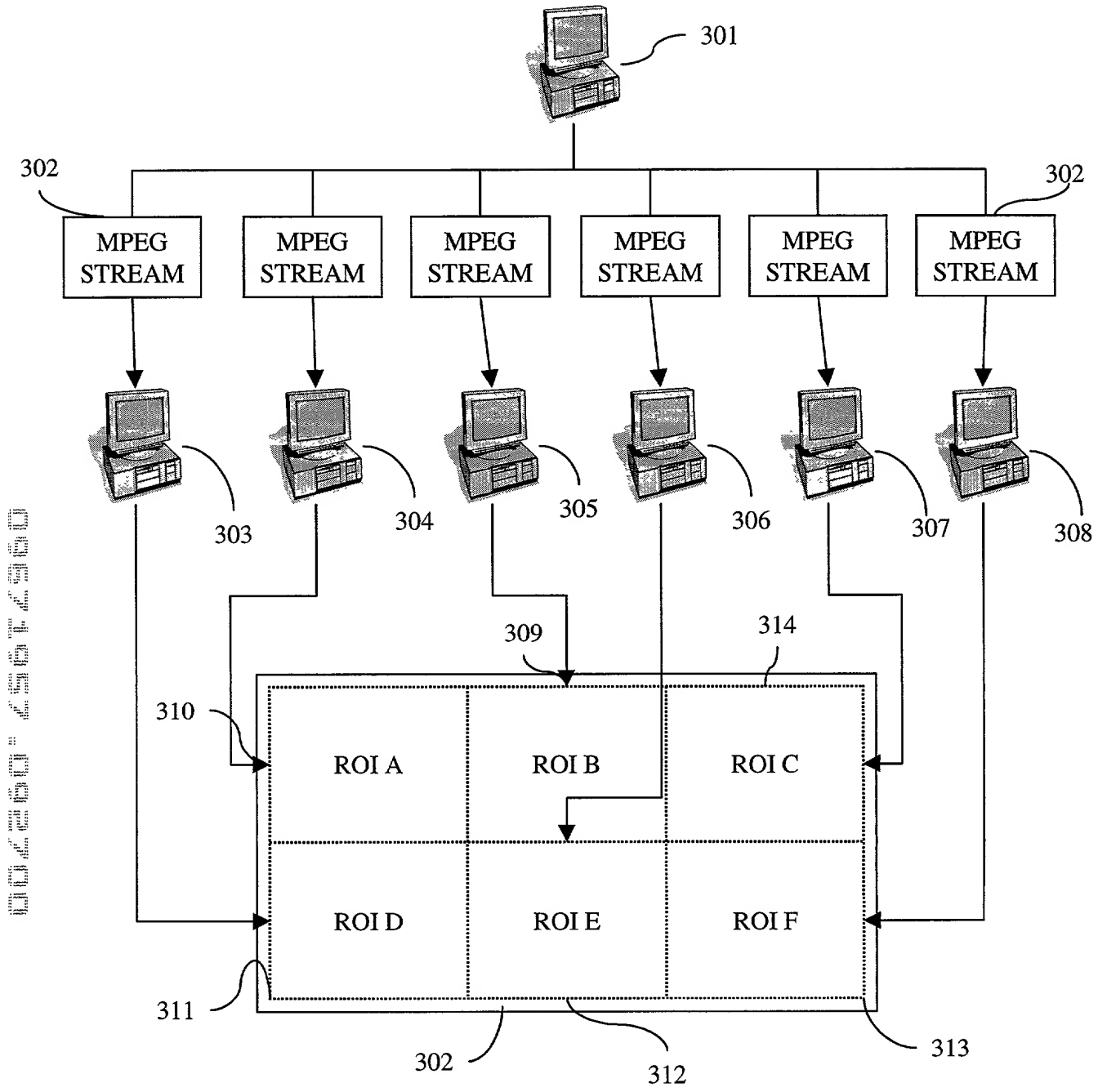

301
302
302
MPEG STREAM
MPEG STREAM
MPEG STREAM
MPEG STREAM
MPEG STREAM
MPEG STREAM
303
304
305
306
307
308
309
314
310
ROI A
ROI B
ROI C
ROI D
ROI E
ROI F
311
302
312
313

Fig. 3

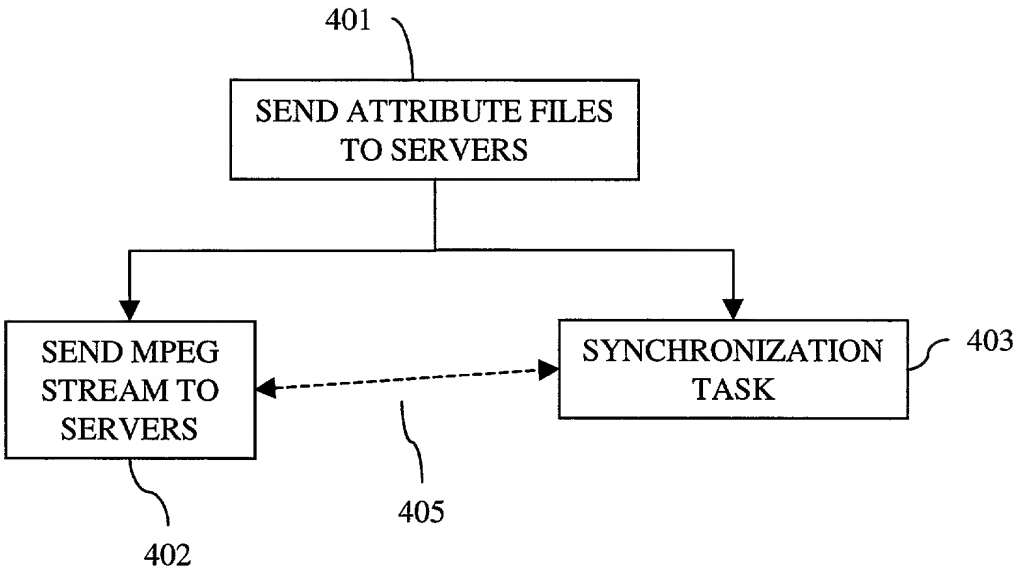

401
SEND ATTRIBUTE FILES TO SERVERS
SEND MPEG STREAM TO SERVERS
SYNCHRONIZATION TASK
403
405
402

Fig. 4

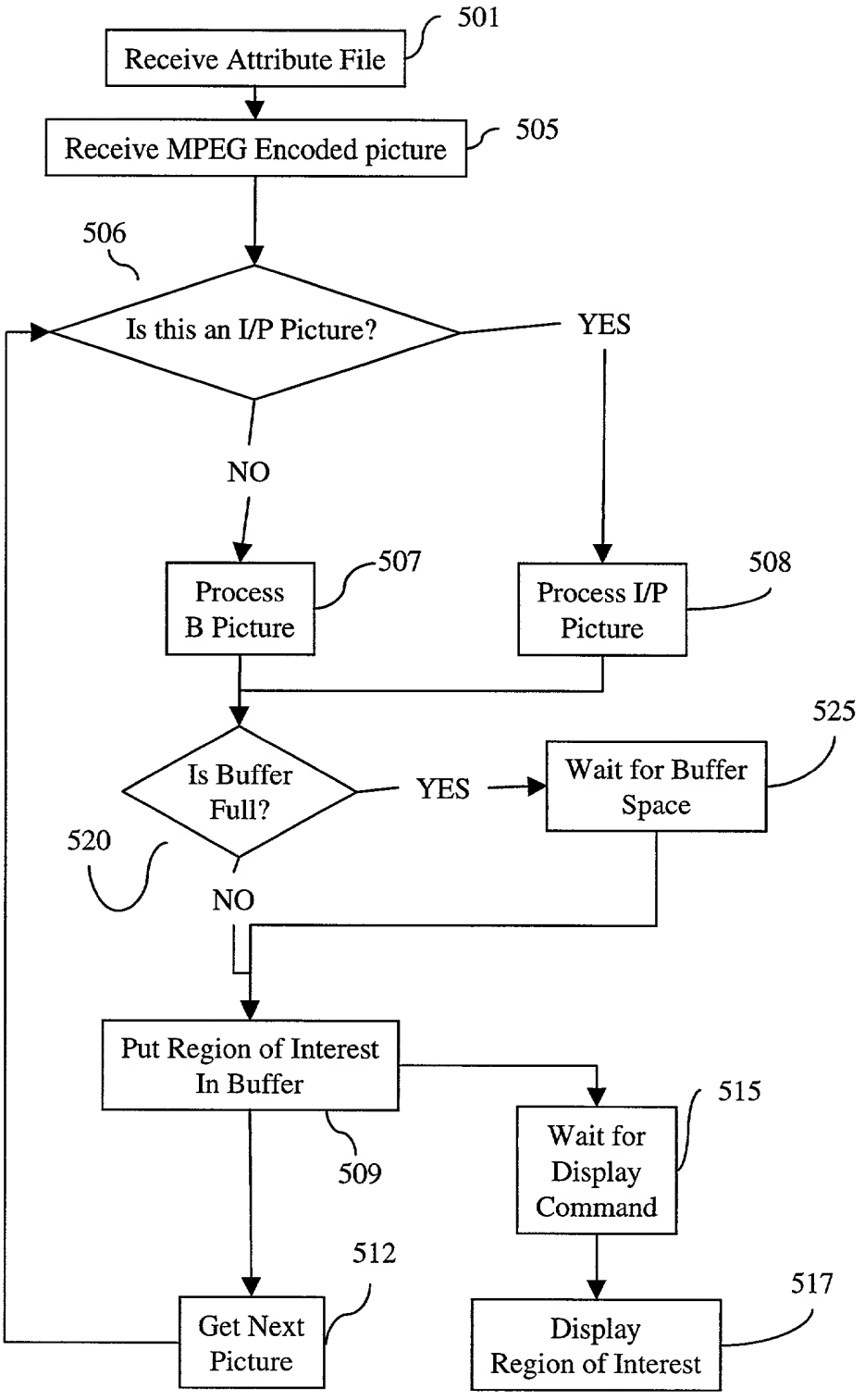

501
Receive Attribute File
505
Receive MPEG Encoded picture
506
Is this an I/P Picture?
YES
NO
507
Process B Picture
508
Process I/P Picture
525
Is Buffer Full?
YES
Wait for Buffer Space
520
NO
Put Region of Interest In Buffer
509
515
Wait for Display Command
512
Get Next Picture
517
Display Region of Interest

Fig. 5

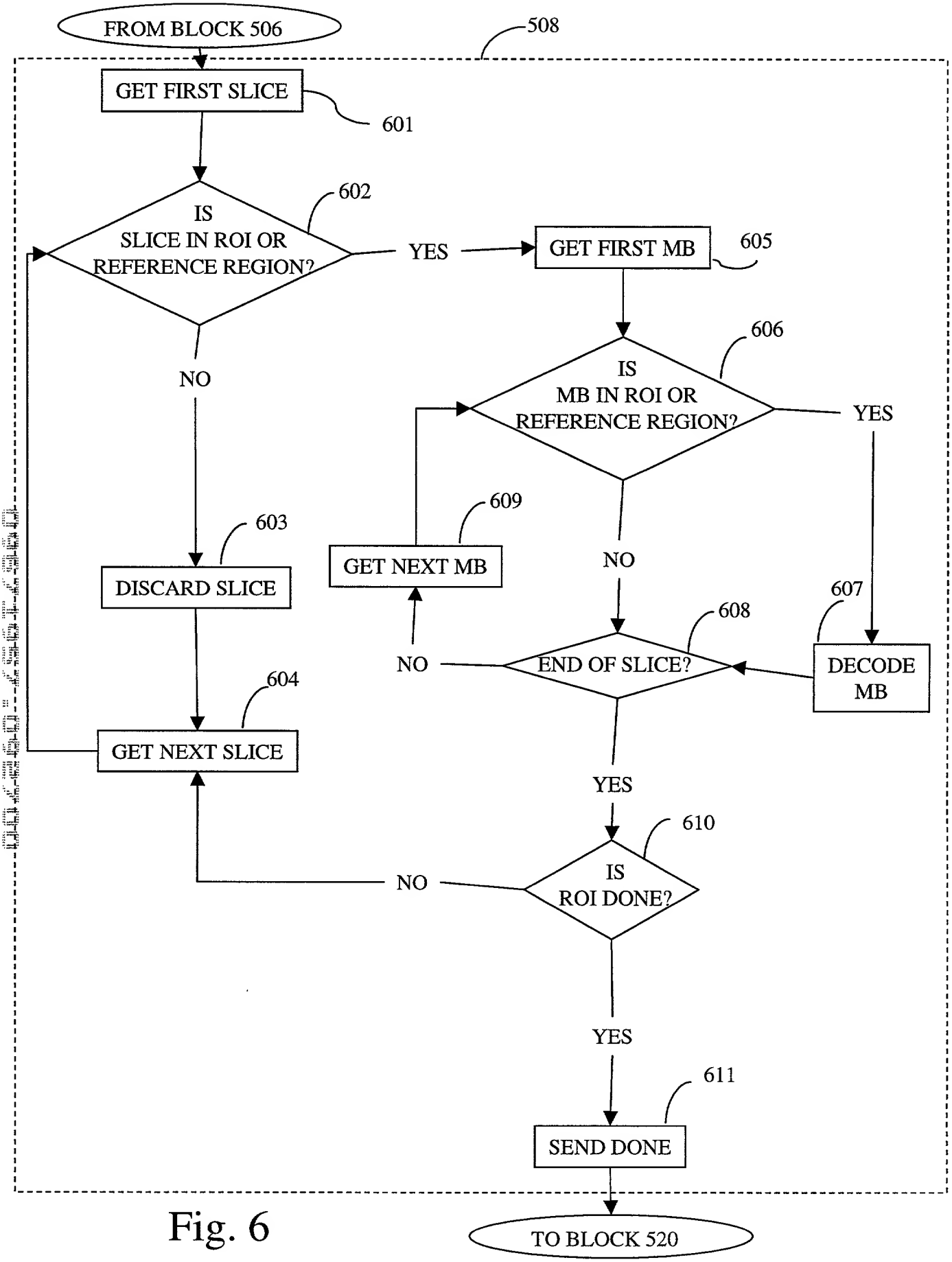

FROM BLOCK 506
508
GET FIRST SLICE
601
IS SLICE IN ROI OR REFERENCE REGION?
602
YES
GET FIRST MB
605
NO
IS MB IN ROI OR REFERENCE REGION?
606
YES
NO
609
GET NEXT MB
603
DISCARD SLICE
607
DECODE MB
608
NO
END OF SLICE?
604
GET NEXT SLICE
YES
610
NO
IS ROI DONE?
YES
611
SEND DONE
TO BLOCK 520

Fig. 6

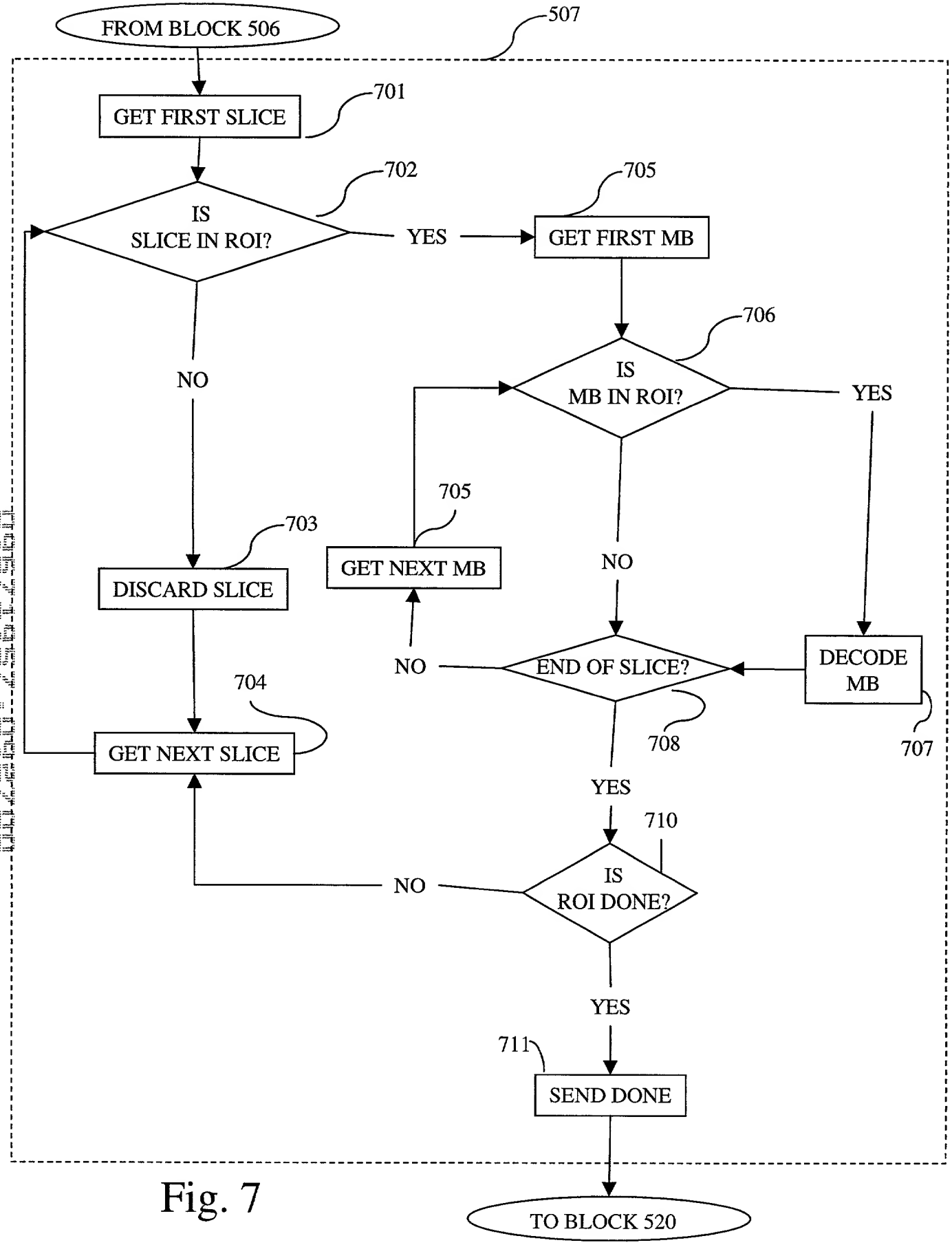

FROM BLOCK 506
507
GET FIRST SLICE
701
IS SLICE IN ROI?
702
YES
NO
GET FIRST MB
705
IS MB IN ROI?
706
YES
NO
GET NEXT MB
705
DISCARD SLICE
703
NO
END OF SLICE?
DECODE MB
707
708
GET NEXT SLICE
704
YES
710
NO
IS ROI DONE?
YES
711
SEND DONE
TO BLOCK 520

Fig. 7

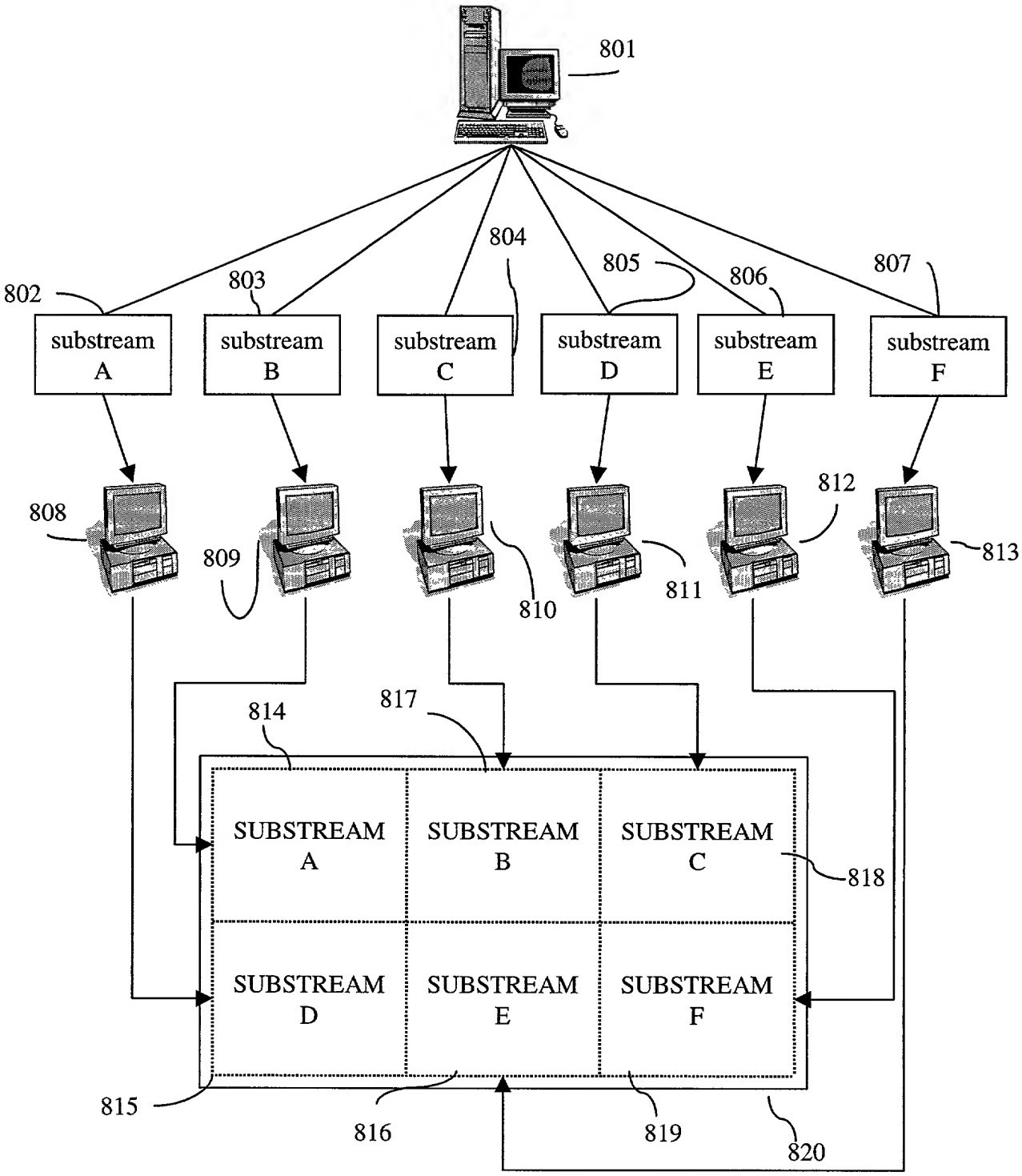

801
802
803
804
805
806
807
substream A
substream B
substream C
substream D
substream E
substream F
808
809
810
811
812
813
814
817
SUBSTREAM A
SUBSTREAM B
SUBSTREAM C
SUBSTREAM D
SUBSTREAM E
SUBSTREAM F
818
815
816
819
820

Fig. 8

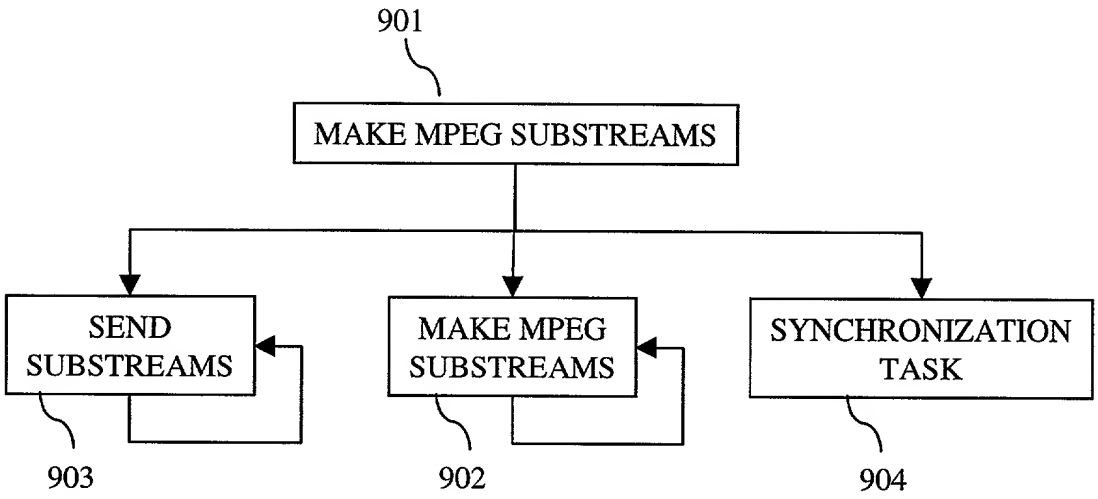

901
MAKE MPEG SUBSTREAMS
SEND SUBSTREAMS
MAKE MPEG SUBSTREAMS
SYNCHRONIZATION TASK
903
902
904

Fig. 9

Fig. 10

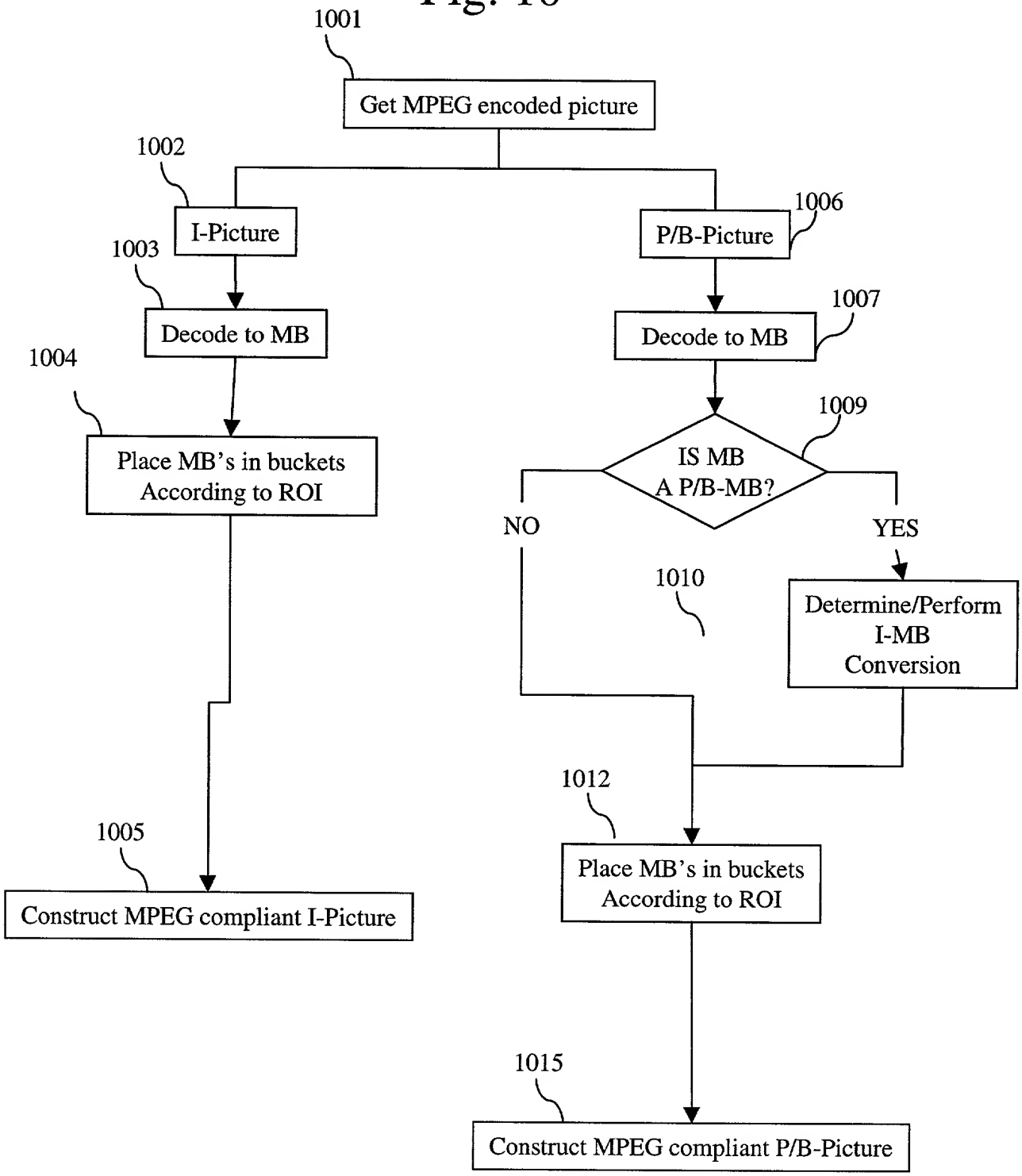
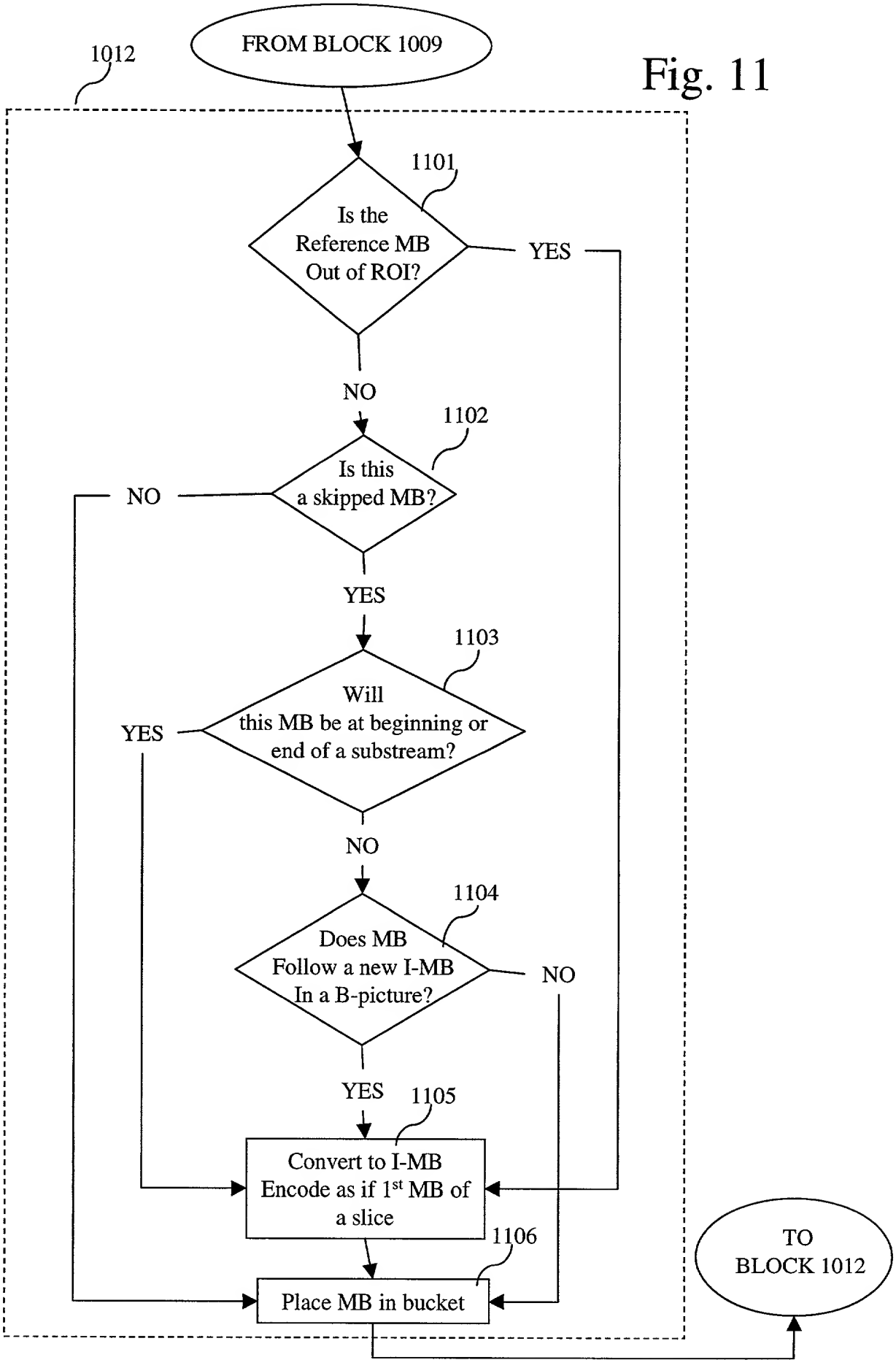

1001
Get MPEG encoded picture
1002
I-Picture
1003
Decode to MB
1004
Place MB's in buckets According to ROI
1005
Construct MPEG compliant I-Picture
1006
P/B-Picture
1007
Decode to MB
1009
IS MB A P/B-MB?
NO
YES
1010
Determine/Perform I-MB Conversion
1012
Place MB's in buckets According to ROI
1015
Construct MPEG compliant P/B-Picture

Fig. 11


1012
FROM BLOCK 1009
1101
Is the Reference MB Out of ROI?
YES
NO
1102
Is this a skipped MB?
NO
YES
1103
Will this MB be at beginning or end of a substream?
YES
NO
1104
Does MB Follow a new I-MB In a B-picture?
NO
YES
1105
Convert to I-MB Encode as if 1st MB of a slice
1106
Place MB in bucket
TO BLOCK 1012

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION
(FOR INTEL CORPORATION PATENT APPLICATIONS)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

METHOD AND APPARATUS FOR MANIPULATING MPEG VIDEO

the specification of which

X is attached hereto.
___ was filed on _____ as
United States Application Number _____
or PCT International Application Number_____
and was amended on _____.
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to this application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

Priority Claimed

(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below:

Application Number	Filing Date
Application Number	Filing Date

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Application Number	Filing Date	Status -- patented, pending, abandoned
Application Number	Filing Date	Status -- patented, pending, abandoned

I hereby appoint the persons listed on Appendix A hereto (which is incorporated by reference and a part of this document) as my respective patent attorneys and patent agents, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

Send correspondence to Daniel M. De Vos, Reg. No. 37,813, BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP, 12400 Wilshire Boulevard 7th Floor, Los Angeles, California 90025 and direct telephone calls to Daniel M. De Vos, Reg. No. 37,813, (408) 720-8598.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Sole/First Inventor Inching Chen

Inventor's Signature _____ Date 9/21/2000

Residence Portland, Oregon (City, State) Citizenship USA (Country)

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APPENDIX A

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APPENDIX B

Title 37, Code of Federal Regulations, Section 1.56
Duty to Disclose Information Material to Patentability

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclosure information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclosure all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) Prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) The closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made or record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application;

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.